SOIL MANAGEMENT AND BASAL LEAF REMOVAL EFFECTS ON MICROCLIMATE, YIELD, FRUIT COMPOSITION ON THE PORTUGUESE VINE VARIETY 'FERNÃO PIRES' IN BAIRRADA REGION

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Abstract:

The study, throughout two years (2004 and 2005), of different systems of soil management, as well as different basal leaf removal modalities, effects on the white variety 'Fernão Pires', took place in a vineyard pertaining to Sogrape Vinhos, SA, located in the Bairrada Demarcated Region (littoral/centre of Portugal).
Two techniques of soil management between rows were applied: the permanent natural grass cover and tillage, both with application of herbicide on the row. In 2004, basal leaf removal was carried through at veraison on the two sides of canopy or only on the East side. In 2005, other basal leaf removal modalities were introduced, at pea size or at veraison, applied only on one or two faces of canopy.
In the two years of the experiment, the climate during the vegetative cycle was dry, especially in 2005. In consequence the predawn leaf water potential reached very low values along ripening and differences between grass covered and tilled treatments have not been registered. Higher net photosynthetic rates were obtained in tilled treatment, probably due to greater magnesium content in the leaves.
Grass cover conduced to a less dense canopy, especially in 2005, by a reduction of the leaf layer number (LLN), higher penetration of photosynthetically active radiation (PAR) at cluster zone and in 2005, provoked a drastic increase on the proportion of sunburned leaves and scalded clusters. On the other hand, basal leaf removal also modified the canopy structure, reducing its density, particularly in 2004. In this year, high bunch rot (*Botrytis cinerea* L.) incidence occurred and the reduction of canopy density had an important role on it's the decrease.
In 2004, yield components hadn't been significantly affected by any of the factors in study. However in 2005, although basal leaf removal haven't influenced yield, grass cover strongly reduced it (about 50%).
Vigour reduction was verified in both years only by grass cover. Small differences between treatments were found in what concerns to must composition. At harvest in 2005, soil management techniques didn't influenced nutritional cluster composition.

Keywords: Soil management, basal leaf removal, sunburn, canopy structure, yield, vigour.

INTRODUCTION

Fernão Pires *cv* (sin. Maria Gomes) is the most cultivated Portuguese white vine variety. It's very productive, with a downward position and has an early budburst, becoming it very sensible to late spring frosts. It's resistant to oidium, but sensible to mildium and bunch rot (Dias *et al.*, 1990).
Traditionally, most of Bairrada's vineyards are strongly and deeply tilled (Castro *et al.*, 1999). The combination of some cultivation techniques as tillage, fertilization and pesticides application, can result in excessively vigorous vineyards (Percival *et al.*, 1994) with dense and shaded canopies, which are adverse environments to the production of quality grapes (Zoecklein *et al.*, 1992) and favourable to cryptogamic diseases, as bunch rot (*Botrytis cinerea*) that often originates great losses, in this region.
Soil grass cover it's an option of soil management that can provoke an evapotranspiration increase, reducing vines vigour, canopy density and conducing to higher quality grapes, but with lower azote content (Le Gof-Guillou *et al*, 2000). However, Olmstead *et al* (2001) has found no significant effect of cover crops on vine water status. On the other hand, although they have registed a decrease plant azote content with natural grass cover, few evidences of grass cover hydric competition were found. According to Keller (1997) and Morlat & Jacquet (1993) the grass cover can contribute to an increase of permutable K_2O.
Basal leaf removal is an operation made to achieve a higher penetration of sunlight in fruit zone, favouring ripening (Payan, 1997), although Hunter *et al* (1995) didn't noted differences between grapes coming from defoliated and non-defoliated vines.

Due to the augmentation of canopy porosity, in fruit zone, basal leaf removal facilitates air circulation, increases potential evapotranspiration, clusters exposition to sunlight and their temperature, disfavouring the infection and the growth of fungus Morlat & Geoffrion (2000). Chellemi & Marois (1992) also defend that one of the most important benefits of basal leaf removal is the increase of fungicides application efficacy.

Castro & Cruz (2001) admit that the ripening period is an interesting time to make this operation. On the other hand, May *et al.* (1969) say that berries adapt better to direct sunlight exposition, if basal leaf removal is done in an earlier stage and Hunter & Visser, (1988) say that basal leaves have a major contribution for berries until pea size.

2. MATERIAL AND METHODS

The vineyard where the trial took place belongs to the company Sogrape Vinhos, SA and it's located in Bairrada Demarcated Region.

Climate in this region, according to Thornthwaite hydric balance, is moderately humid, mesothermic, with a moderate lack of water in summer and meanly tempered and pluvious in winter (Castro *et al.*, 1999), with an average rainfall of 1010mm per year. The soil is neutral (pH_{H2O} = 7) at the 0-20cm level and moderately acid at 20-50cm (pH_{H2O} = 6), the organic matter content is medium (3,50%) and texture is gross. The vineyard, planted in 1987, grafted onto SO4, has a 2,5m x 1,25m compass, is trained on a bilateral Royat Cordon and vegetation is vertical shoot positioned. The pruning system is a Royat Cordon and potential crop is 20 buds per vine. Lines are oriented in N-S direction.

Two soil management techniques were assayed, one with soils tillage (TIL) and the other with permanent natural grass cover on the inter-row. On both was made herbicide application on the row.

The basal leaf removal trial has been different among 2004 and 2005. So in 2004 we had 2 basal leaf removal alternatives (V1 – at veraison, on the east side of canopy; V2 – at veraison, on both sides of canopy). In 2005, we had 5 basal leaf removal alternatives (PS1 – at pea size on the east side of canopy; PS2 – at pea size on both sides of canopy; V1 - at veraison on the east side of canopy; V2 - at veraison on both sides of canopy; T – no leaf removal).

For the evaluation of canopy structure, has been measured canopy density, by Point Quadrat method (Smart & Robinson, 1991), canopy dimensions and photosynthetic active radiation (PAR), with a ceptometer.

Ecophysiological behaviour has been analysed through the leaf gas exchanges, with a portable IRGA system (model ADC-LCA4), and the leaf water potential (ψ), with a pressure chamber (Scholander type).

To characterize the agronomical behaviour, has been counted the clusters number per vine and its weight. To evaluate vines vigour, has been registered the shoots number per vine and its weight.

During 2005, were done 3 floristic surveys, to characterize the grass cover flora. In this year, at harvest, was observed the leaves senescence and the proportion of sunscalded clusters.

A nutritional characterization of vines was made at blooming in both years. In 2005 was also made the grapes nutritional characterization. A split-plot experiment was designed, with 2 replications.

3. RESULTS AND DISCUSSION

3.1 – Climate

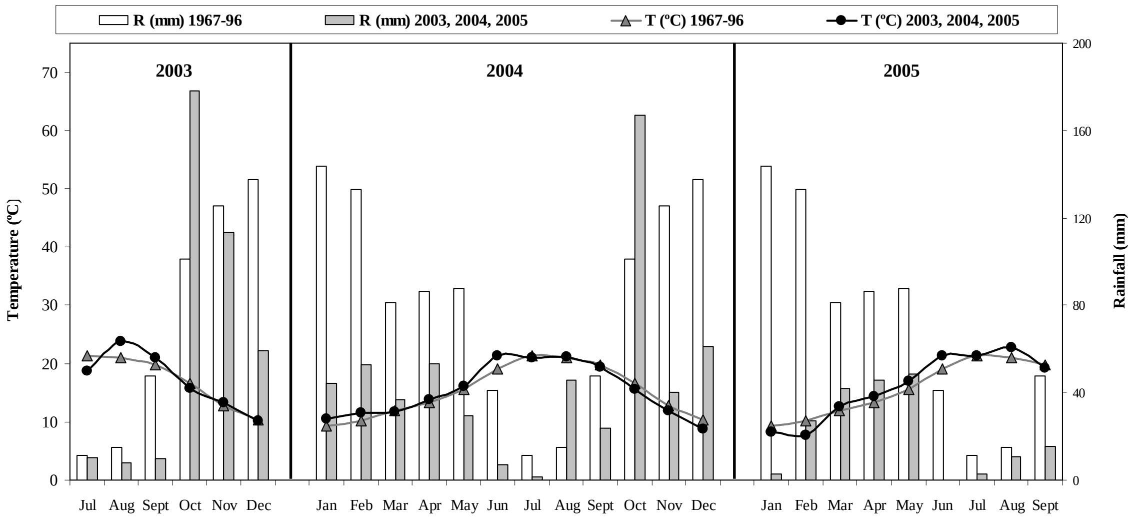

Figure 1 – Rainfall and average temperature during the trial compared with the average of 30 years (1967-1996).

Climate, along the 2 years of the experiment, was very different. We can observe, on figure 1, that the average mensal temperature, of 2004, was normal for the region and only in June it has been significantly superior to the 30 years average (1967-1996). In 2005, we verify that, since March, the temperatures were higher than the 30 years average.

In 2004, rainfall was inferior to the average, with exception for August and October. We can also observe that the end of 2003 has been very rainy, leading to a soil water storage that permitted a reasonable water supply to the plants, during the summer of 2004. In 2005, the rainfall during winter was evidently low, conducing to an incorrect water supply to plants during summer, which is reflected by the predawn leaf water potential values observed.

3.2 – Ecophysiological behaviour

On figure 2, no significant differences of predawn leaf water potential (Ψ_p) between soil management treatments were found, as referred by Olmstead *et al* (2001). It is also observed that the Ψ_p never reached values of severe hydric stress and, due to the occurrence of some precipitation during August, it recovered to higher values at the end of season. In 2005, Ψ_p reached very low values for this sensible vine variety.

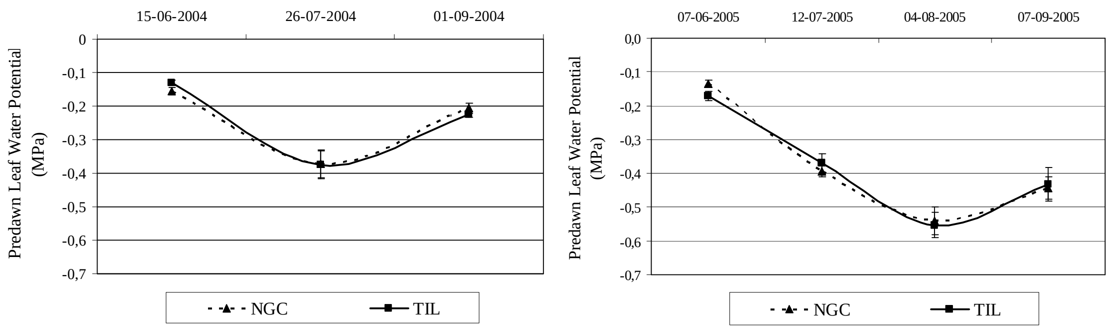

Figure 2 – Seasonal predawn leaf water potential evolution in 2004 and 2005. Average of 12 leaves ± SE.

The photosynthetic rate and leaf temperature are presented on figure 2. It’s evident that in both years the leaves from grass cover treatment, except on 12 of June of 2004, presented higher temperatures and lower photosynthetic rates. It can also be observed a decline of photosynthetic rates along the cycle, which, in part, derives from the aging of leaves.

It's also shown that, during 2004, photosynthetic rates never reached considerable low values, even at the end of the cycle, and that differences between the 2 treatments, although significant, have never been as high as in 2005 (figure 2).

Analysing photosynthetic rates, measured on 12 of July and on 2 of August of 2005 (figure 2), it's evident that, on the first date, leaves from both soil management treatments presented reasonable photosynthetic levels, yet grass cover treatment was photosynthesising at lower levels. On the second date differences were smaller and photosynthetic rates reached relative low values, although leaves temperature maintained similar.

The lack of differences in Ψ_p suggests that the nutritional disequilibrium (table 5) is probably the main factor for the differences verified on photosynthetic rates.

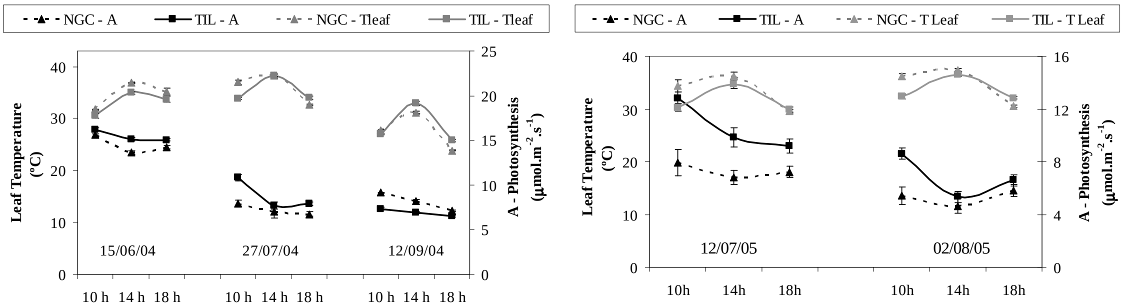

Figure 2 – Diurnal and seasonal evolution of net photosynthesis and leaf temperature, in 2004 and 2005. Average of 12 leaves ± SE.

3.3 – Canopy Structure

Table 1 – Influence of basal leaf removal and soil management on canopy structure and microclimate during the ripening of 2004. NGC – natural grass cover; TIL – tilled; V1 - basal leaf removal at veraison on one side of canopy; V2 - basal leaf removal at veraison on both sides of canopy.

	LLN	% of shaded clusters	PAR at clusters level	ESA (m2/ha)
NGC	0,86	24,9	437,6	8901
TIL	0,94	19,4	327,0	9716
Sig.	*n.s.*	*n.s.*	**	***
V1	1,30	30,9	299,6	9500
V2	0,49	13,3	465,1	9116
Sig.	***	***	***	*

Note: Sig. – Significance level; n.s. – non significant at 5% level by F test; significant at 5% level (*), 1%(**) e 0,1%(***), by Tukey HSD test. Values followed by equal letters don't differ significantly, at 5% by Tukey HSD test.

Table 2 – Influence of basal leaf removal and soil management on canopy structure and microclimate during the ripening of 2004. NGC – natural grass cover; TIL – tilled; PS1 – basal leaf removal at pea size on one side of canopy; PS2 – basal leaf removal at pea size on both sides of canopy; V1 - basal leaf removal at veraison on one side of canopy; V2 - basal leaf removal at veraison on both sides of canopy; T – without basal leaf removal.

Treatment	LLN	% of shaded clusters	PAR at clusters level	% sunburned leaves	% scalded clusters	ESA (m2/ha)
NGC	2,17	60,5	599,6	40,7	34,6	9836
TIL	2,64	62,4	267,7	31,1	19,9	11233
Sig.	*	*n.s.*	***	***	***	***
PS1	2,40 b	59,0 ab	410.9	32,7	20,3	10413 bc
PS2	1,77 b	50,0 b	459,8	30,5	33,4	10070 bc
V1	2,54 b	67,6 ab	463,3	40,4	27,6	10688 b
V2	1,74 b	51,0 b	416,8	35,0	30,5	9980 c
T	3,40 a	79,0 a	417,5	40,8	24,5	11491 a
Sig.	*	*	*n.s.*	*n.s.*	*n.s.*	*

Note: Sig. – Significance level; n.s. – non significant at 5% level by F test; significant at 5% level (*), 1%(**) e 0,1%(***), by Tukey HSD test. Values followed by equal letters don't differ significantly, at 5% by Tukey HSD test.

On tables 1 and 2, is observed that grass cover had a non significant influence on LLN at fruit zone in 2004. In 2005, the differences between grass cover and tillage treatments were also small, but statistically significant. However, these slight differences on LLN reflected on an

accented increase of PAR interception at fruit zone, especially in 2005 where the differences were near the 300 $\mu mol.m^{-2}.s^{-1}$ (about 124%).
On the other hand, LLN at fruit zone has been reduced by basal leaf removal on both years, originating a sparse canopy, with improvement on PAR interception.
In 2005, the defoliated treatments presented a smaller LLN value, although differences between different stages and intensities of leaf removal aren't significant. However, the results suggest that leaf removal on one side of the canopy (PS1 and V1) conduces to higher LLN than on both sides (PS2 and V2) and leaf removal date doesn't induce differences on this parameter. There is also to refer that, in 2005, PAR interception at fruit zone hasn't been affected by leaf removal.
It's evidenced that leaf removal has been very efficient in reducing the proportion of shaded clusters, what doesn't happen with grass cover, which in both years didn't have any effect on this parameter.
A factor that, in 2005, presents a high correlation with the differences of PAR interception on fruit zone, and that seems to be on these origin, is basal leaves senescence. On table 2 is presented the proportion of sunburned leaves, which shows that grass cover induced a significant increase of leaf senescence.
This strong basal leaves senescence in 2005 is the vines response to climatic conditions. In addition, 'Fernão Pires' vine variety reveals susceptibility to dry conditions, as referred by Castro & Lopes (1990), as well as rootstock SO4 where it is grafted.
In 2005, the proportion of sunburned clusters has been observed and it showed a high correlation with the proportion of sunburned leaves and, consequently, with grass cover. Leaf removal didn't have any significant effect on this parameter, although both sides defoliated treatments show a higher tendency to greater levels of sunburned clusters. So, it leads us to think that in dry and hot years, as 2005, leaf removal on both sides of canopy may not be the better option. It's also clear that most of sunburned clusters are on the west side of canopy (92%), which is related to the fact that this side of canopy is exposed to sunlight during the afternoon, period when temperature is higher.
The exposable surface area (ESA) was significantly increased on both years by tillage, due to the higher plants vigour in this treatment.

3.4 – Agronomic results
In table 3, yield components are presented and can be concluded that in 2004 yield and its components haven't been significantly affected by any of the studied factors, except the cluster weight, that has been slightly improved by soil tillage.
In 2005, soil grass cover provoked a high significant yield reduction and basal leaf removal origin less significant losses of this factor. It's also seen that cluster number per vine is significantly higher on tilled treatment. The lower cluster number and cluster weight, provoked by greater sunburn, induced a decrease in yield around 100%, on grass covered treatments. On the other hand, leaf removal conduced to differences only at cluster weight. This result had been referred by May *et al.* (1969) and is originated by clusters habituation to sunlight, before veraison, improving their resistance to sunburn during ripening. The treatment without leaf removal showed a tendency to higher yield.
The reduction of canopy density and microclimate improves at fruit zone by soil grass cover, as well by leaf removal, conduced to a decrease of bunch rot incidence as observed by Morlat & Geoffrion (2000).

Table 3 – Influence of basal leaf removal and soil management on yield, exposable surface area and on their relation, in 2004 and 2005. NGC – natural grass cover; TIL – tilled; PS1 – basal leaf removal at pea size on one side of canopy; PS2 – basal leaf removal at pea size on both sides of canopy; V1 - basal leaf removal at veraison on one side of canopy; V2 - basal leaf removal at veraison on both sides of canopy; T – without basal leaf removal.

Year	Treatment	Clusters/Vine	Cluster weight (g)	Yield (t/ha)	Bunch rot incidence (%)	ESA/Yield (m^2/Kg)
2004	**TIL**	23,0	149	10,8	50,4	0,90
	NGC	23,5	136	10,2	42,1	0,87
	Sig	*n.s.*	*	*n.s.*	-	*n.a.*
	V1	23,2	141	10,3	49,4	0,92
	V2	23,3	144	10,7	43,2	0,85
	Sig	*n.s.*	*n.s.*	*n.s.*	-	*n.a.*
2005	**TIL**	21,4	184,4	12,3	5,0	0,91
	NGC	18,2	111,9	6,6	4,8	1,49
	Sig	***	***	***	-	*n.a.*
	PS1	19,3	146,5 ab	9,5 ab	3,9	1,10
	PS2	18,9	168,8 a	9,7 ab	4,0	1,04
	V1	19,3	141,7 ab	8,9 ab	4,4	1,20
	V2	20,3	125,8 b	8,3 b	5,1	1,20
	T	21,2	158,7 ab	10,7 a	7,0	1,07
	Sig	*n.s.*	*	*	-	*n.a.*

Note: Sig. – Significance level; n.s. – non significant at 5% level by F test; significant at 5% level (*), 1%(**) e 0,1%(***), by Tukey HSD test. Values followed by equal letters don't differ significantly, at 5% by Tukey HSD test.

The vigour, on both years, is presented on table 4. We can see that in 2004 the shoot number per meter of row hasn't been influenced by soil management, contrarily to 2005, where tilled soil present higher values. The significant differences in 2005 were due to the greater water shoots number, as a result of higher vigour on tilled soil.

Soil grass cover induced a lower shoot weight, on both years. The decrease in vigour provoked by grass cover was also reported by many authors as Le Gof-Guillou *et al*, (2000) and Morlat & Geoffrion, (2000).

Grass cover effect on Ravaz Index was contrary on 2004 and 2005. On 2004, the grass cover induced an enhancement, due to a reduction in vegetative expression, while on 2005, the significant loss of yield, reduced Ravaz Index.

Table 4 – Influence of basal leaf removal and soil management on vigour and vegetative expression. NGC – natural grass cover; TIL – tilled; BLR1 – with basal leaf removal; BLR0 – without basal leaf removal; PS1 – basal leaf removal at pea size on one side of canopy; PS2 – basal leaf removal at pea size on both sides of canopy; V1 - basal leaf removal at veraison on one side of canopy; V2 - basal leaf removal at veraison on both sides of canopy; T – without basal leaf removal.

Year	Treatment	Shoots/vine	Pruning weight (kg/vine)	Shoots/m	Shoot weight (g)	Ravaz Index
2004	**TIL**	17,8	0,83	14,3	47,5	4,1
	NGC	18,1	0,60	14,5	34,3	5,3
	Sig	*n s*	***	*n s*	***	*ns*
2005	**TIL**	16,3	0,96	13,0	61,2	4,5
	NGC	14,5	0,59	11,6	41,0	3,7
	Sig	***	***	***	***	**

Note: Sig. – Significance level; n.s. – non significant at 5% level by F test; significant at 5% level (*), 1%(**) e 0,1%(***), by Tukey HSD test. Values followed by equal letters don't differ significantly, at 5% by Tukey HSD test.

3.5 – Nutritional characterization

At full bloom nutritional characterization was made (table 5). The analysis of this table reveals a nutritional disequilibrium, on magnesium and potassium levels. This disequilibrium, evidenced by K/Mg relationship, is more expressive on grass cover treatments, as a result of potassium increase content and a reduction of magnesium, particularly in 2005. The excess of potassium inhibited the absorption of other elements, namely magnesium. The magnesium content under the recommended values, on grass cover soil, reduced the photosynthetic rate. This increase of potassium disposability, on soil, in the grass covered treatment has also been referred by Keller (1997) e Morlat & Jacquet (1993).

Azote levels are identical on both soil management techniques, in 2005, yet under the recommended values. In 2004, the lower value observed in the grass cover treatment, in our opinion, was the most important cause for vigour reduction.
Contrarily to other authors, at harvest, no significant differences on grapes nutritional composition, between different soil management techniques, were obtained (table 6).

Table 5 – Influence of soil management on leaves nutritional composition, at full bloom in 2004 and 2005. NGC – natural grass cover; TIL – tilled.

Year	Soil management	N	P	K	Ca	Mg	K/Mg	B	Zn	Mn
2004	**TIL**	10,1	2,8	30,5	31,1	3,1	10,0	40,1	44,0	43,5
	NGC	7,3	2,6	31,4	24,3	3,0	10,7	36,6	43,5	52,0
2005	**TIL**	8,1	2,4	31,5	27,1	3,5	10,7	29,5	45,5	77,0
	NGC	8,1	3,0	41,0	27,4	2,4	18,0	31,0	52,5	45,0
	Recommended values	9-12	2-4	15-25	14-28	2,5-5	4-8	30-80	25-100	30-150
		g/kg						mg/kg		

Table 6 – Influence of soil management on grapes nutritional composition at harvest in 2005. NGC – natural grass cover; TIL – tilled.

Soil management	mg/100 g of grapes										
	N	**P**	**K**	**Ca**	**Mg**	**S**	**Fe**	**Mn**	**Zn**	**Cu**	**B**
NGC	122,2	21,1	208,0	31,8	8,2	25,7	0,65	0,14	0,11	0,34	0,13
TIL	120,7	19,1	206,0	29,2	7,4	23,0	0,50	0,12	0,10	0,16	0,19

3.6 – Grass cover characterization

Table 7, present the biomass percentage, of each specie, on grass cover soil, during 2005. In all data collection the dominant specie is *Holcus lanatus* L. This gramineous is a rhizomatous and perennial specie, which forms a grass cover that difficult the development of other species. Although, in this trial field this is a spontaneous specie, is referred by Amaro *et al* (2001), as a preferential one to install grass covering on vineyards.

Table 7 – Biomass percentage of the species constituent of the natural grass cover, on three dates, during the 2006 vegetative cycle.

Specie	08-Jun-05	02-Sep-05	04-Nov-05
Andryala integrifolia		5,9	
Coleostephus myconis L.	1,7		
Convolvulus arvensis L.			0,8
Cynodon dactilon L.		23,0	
Erodium moschatum (L.) L´Hér.			13,3
Geranium molle L.			3,9
Holcus lanatus L.	91,7	68,2	76,4
Hypericum humifusum L.	0,2		
Lavatera cretica L.	0,6		0,0
Lolium multiflorum Lam.		3,0	
Malva sylvestris L.	2,5		
Ornithopus compressus			1,4
Poa annua L.			1,1
Polycarpon tetraphyllum			0,3
Rhaphanus raphanistrum L.			0,8
Rumex crispus L.	1,2		
Rumex pulcher L.			1,4
Sinapsis arvensis L.			0,3
Sonchus oleraceus L.			0,1
Spergularia purpurea (Presl.)G.Don.fil.			0,2
Trifolium campestre Schreber	1,7		
Trifolium resupinatum L.	0,3		0,2

3.7 – Must composition

Through the analysis of must composition, presented on table8, first of all, we can see that in both years the introduced treatments didn't provoke considerable effects on must composition, however some tendencies are observed.

Natural grass cover induced a slight decrease of probable alcoholic content (PAC) on both years, with a small increase of the titrable acidity in 2004. A reduction in tartaric acid and an increase in malic was verified in tilled soil. This relationship can be important, at oenological level, because in white wines the malo-lactic fermentation is usually inhibited and tartaric acid is more stable than malic.

Basal leaf removal on both sides of canopy reduced titrable acidity in the 2 years. In 2004, that decrease was due to a lower malic acid content, while in 2005, it resulted from the decrease of both acids. On the other hand, basal leaf removal on one side of canopy presented lower values of titrable acidity, comparing to test, but with equal values of tartaric acid.

We also verified a decrease of PAC and titrable acidity, from 2004 to 2005, which is due to the higher hydric stress but principally in result of the extremely hot weather during ripening, that blocked the sugar accumulation and led to greater acids degradation.

Table 8 – Influence of basal leaf removal and soil management on must composition, in 2004. NGC – natural grass cover; TIL – tilled; PS1 – basal leaf removal at pea size on one side of canopy; PS2 – basal leaf removal at pea size on both sides of canopy; V1 - basal leaf removal at veraison on one side of canopy; V2 - basal leaf removal at veraison on both sides of canopy; T – without basal leaf removal.

Year	Treatment	PAC	Titrable Ac. (g/l ac. Tart)	pH	Tartaric Ac. (g/l)	Malic Ac. (g/l)
2004	NGC	12,9	6,85	3,24	3,10	1,95
	TIL	13,1	7,00	3,26	2,80	2,35
	V1	13,2	7,15	3,23	2,95	2,20
	V2	12,8	6,70	3,27	2,95	2,10
2005	NGC	10,7	5,75	3,11	3,97	1,65
	TIL	11,1	5,76	3,16	3,81	2,08
	PS1	10,9	5,88	3,12	4,07	1,81
	PS2	11,2	5,39	3,14	3,68	1,72
	V1	11,0	5,71	3,13	4,01	1,91
	V2	10,7	5,64	3,13	3,66	1,77
	T	10,7	6,15	3,14	4,06	2,11

3.6 – Conclusions

The climate conditions extremely different in relation with the regional average, especially in 2005, definitively marked the results in this particular year.

In the Mediterranean conditions, particularly in dry and hot summers, basal leaf removal only on the East side of canopy, seems to be a good practice, because reduces bunch rot incidence, when compared with non defoliated vines (T) and still maintains good must acidity levels, in relation to both sides basal leaf removal (V2).

In Bairrada region, where traditionally soil tillage is done in early winter, natural grass cover is fundamental to maintain vineyard passable for persons and machinery. However, in very dry years like 2005, superficial tillage in early summer seems to be obligatory, to prevent sunscald of grapes and to obtain economically viable yields. On the other hand, in normal years, like 2004, natural grass cover helps to prevent cryptogamic diseases, without yield or quality losses.

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